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(58) Field of search
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(54) Seals for klystron tubes

(57) An external cavity klystron vacuum tube has a ceramic cylindrical wall surrounded by an external cavity within which is an output probe. The cylindrical wall section 1 is sealed at its ends to other components of the tube 3 – to enable the interior to be evacuated – by sealing means 15 such as to avoid a sharp edge projecting inwardly towards the interior of the cavity. The absence of a sharp edge reduces the tendency for arcing to occur between the seal and the resonant cavity of the klystron.

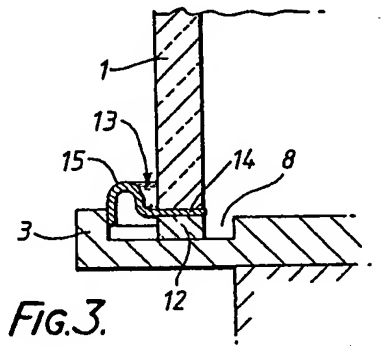

FIG.3.

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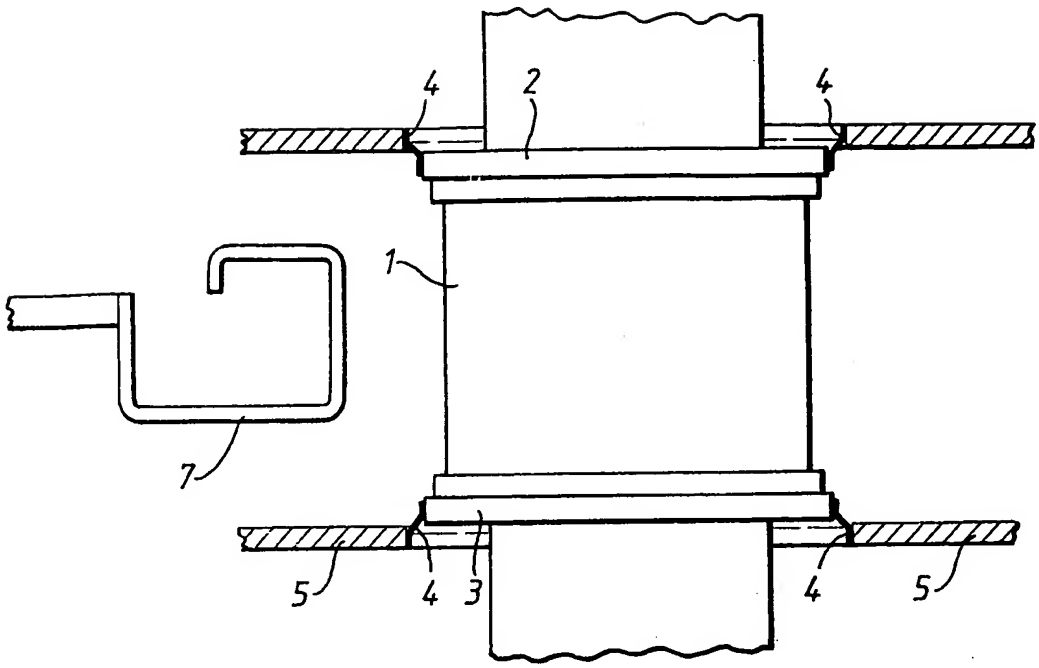

FIG.1.

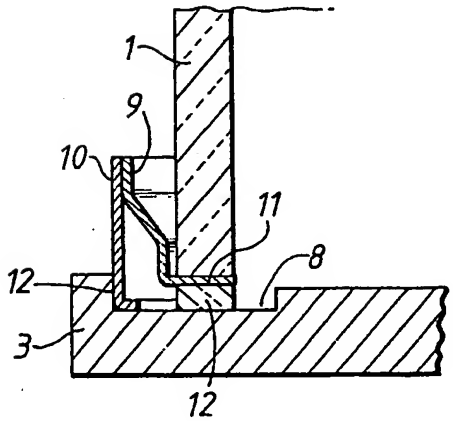

FIG.2.

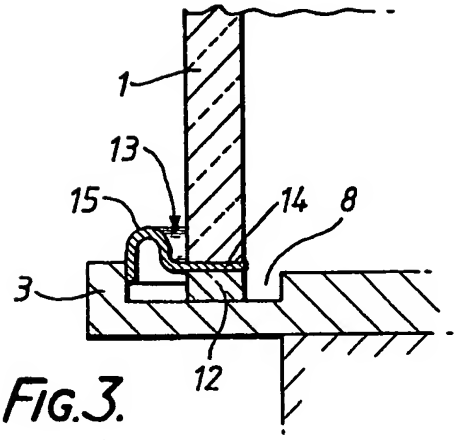

FIG.3.

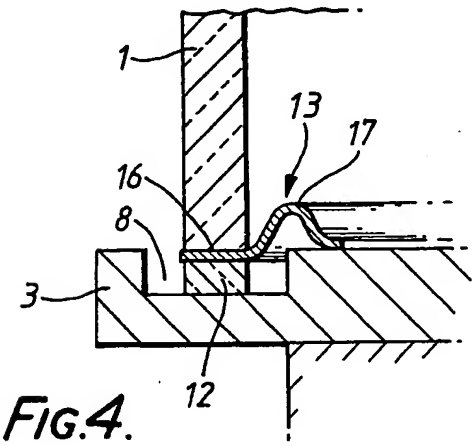

FIG.4.

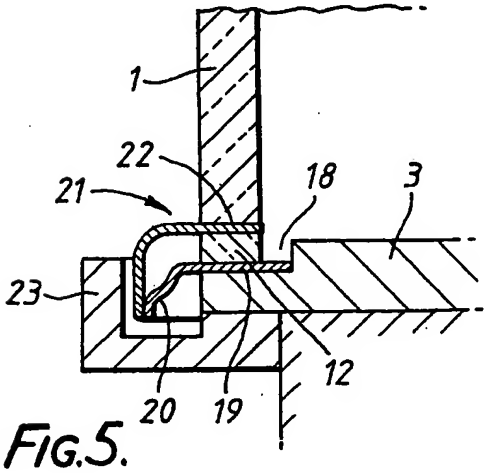

FIG.5.

SPECIFICATION

Improvements in or relating to klystron vacuum tubes

This invention relates to klystron vacuum tubes and in particular to so called external cavity klystron vacuum tubes.

Part of a typical external cavity klystron vacuum tube arrangement as at present known is illustrated in Figure 1.

Referring to Figure 1 the tube comprises a vacuum wall section 1 in the form of a dielectric cylinder transparent to electro-magnetic radiation. This forms a window through which power is effectively transmitted. The cylindrical section 1 has, at either end, cylindrical copper annuli 2,3 which are shaped to receive the ends of the cylindrical wall member 1 and provide, by portions of increased diameter, contact for spring fingers 4 attached to the inner rims of a box member 5 surrounding the cylindrical wall 1 and forming the external cavity. In order to adjust the resonant frequency of the external cavity, a pair of moveable tuning plungers (extending at right angles to the plane of the paper and not shown) is provided, one on each side of the cylindrical wall member 1. To the left (as shown) of the cylindrical wall member 1 is a coupling loop 7, adjustable by rotation, by which output power is coupled to an external transmission line and aerial (not shown).

Particular attention should be given to the method of forming the vacuum seal between the cylindrical wall member 1 and the copper annuli 2,3. Since the cylindrical wall member 1 is normally of a high purity alumina or beryllia ceramic consistent with its function as a window, there will be observed a differential expansion between the cylindrical member 1 and the copper annuli 2,3. The coefficient of expansion of the material of the cylindrical wall member 1 is very much less than that of copper.

In order to accommodate for this differential expansion the joint between the cylindrical wall member 1 and each of the copper annuli 2,3 is normally as shown in more detail in Figure 2.

Referring to Figure 2 it will be seen that the cylindrical wall member 1 is located within a recess 8 in the copper annulus 3 (with a similar arrangement at the other end of the member 1). Use is made of an inner cylindrical flare 9 and an outer cylindrical flare 10. Inner flare 9 is brazed at one end 11 between the end of the ceramic wall member 1 and a ceramic balance ring member 12. The outer flare member 10 is brazed to the outermost wall of the recess 8 in the copper annulus 3. Finally the vacuum seal is completed by welding inner flare member 9 to outer flare member 10.

The whole construction forms a vacuum joint with the balance ring 12 pressing against the copper disc 3 and taking up the axial thrust due to the external pressure when the tube is under vacuum. In addition the balance ring 12 forms a sliding abutment with the base of the recess 8 accommodating for differential expansion between the cylindrical wall member 1 and the copper disc 3.

It has been found that a klystron constructed as described with reference to Figures 1 and 2 suffers from a serious defect. The output cavity 5 operates at the highest power level and the peak radio frequency voltage across the cavity is approximately the same as the operating voltage of the klystron, typically between 20 and 26kV for a high power television klystron. It has been found that arcing sometimes occurs in the cavity which not only can cause puncturing of the seal provided by the flares 9 and 10 but also, of course, interruption of operation if, as is commonly the case, an arc detector is introduced which removes the r.f drive from the klystron upon the detection of an arc.

The present invention seeks to provide an improved construction in which the aforementioned problem is mitigated.

According to this invention an external cavity klystron vacuum tube is provided including a cylindrical section of wall transparent to electro-magnetic radiation and provided to be surrounded by an external resonant cavity, said wall section being sealed at its ends to other components of said tube by sealing means avoiding a sharp edge projecting inwardly towards the interior of said cavity whereby to reduce the tendency for arcing to be induced between the sealing means and the interior of said external resonant cavity or an output probe provided therein.

In a preferred embodiment of the invention each end of said cylindrical wall section is closed by a copper annulus which, towards its outer periphery, has an annular recess, a flexible ring has an inner rim secured between the end of said cylindrical wall section and a balance ring member which bears upon the base of said recess, said ring member having an outer rim formed as a radiused flange which is secured around its periphery to the inner wall of said recess.

Normally said ring is secured between said cylindrical wall section and said balance ring member by brazing and is attached to the inner wall member of said recess, also by brazing.

In another embodiment of the invention each end of said cylindrical wall section is closed by a copper annulus which, towards its periphery, has an annular recess, a flexible ring has an outer rim secured between the end of said cylindrical wall section and a balance ring member which bears upon the base of said recess, said ring member having an inner rim formed as a radiused flange the inner periphery of which is secured to the inner surface of said copper annulus facing the interior of said cylindrical wall section.

Normally said ring is secured between said cylindrical wall section and said balance ring member by brazing.

In another embodiment of the invention each end of said cylindrical wall section is closed by a copper annulus which is stepped at its outer periphery, the inner rim of a flexible ring being secured to the base of said step whilst the outer rim thereof is turned over the outer edge of said copper annulus away from the interior of said cavity,

the inner rim of another flexible ring is secured between the end of said cylindrical wall section and a balance ring member which bears upon the inner rim of said first flexible ring member, the outer rim of said second ring member is turned over the outer edge of said copper annulus away from the interior of said cavity and the outer edges of said two ring members are united. Normally with a construction as described above a collar is provided attached to said annulus and extending over the outer rin of said second ring member, the collars at each end of said wall section providing abutments for the walls forming said external cavity. Normally, as known *per se*, the walls of said external cavity terminate in spring fingers which, in the embodiment just described, bear upon said collars.

Normally said cylindrical wall member and said balance ring member are of ceramic material.

Normally said flexible ring or rings are of cupro-nickel.

In the embodiment described above using two flexible rings the edges of which are united, preferably said edges are united by welding.

Normally each annulus closing an end of said cylindrical wall section are of copper.

The invention is further described with reference to Figures 3, 4 and 5 of the accompanying drawings which illustrate three different embodiments of klystron vacuum tube in accordance with the present invention.

Figures 3, 4 and 5 illustrate detail of the vacuum sealing means provided by the present invention in the way that Figure 2 illustrates the sealing means employed in the conventional tube and like references are used for like parts.

It will be seen that in all three of the embodiments of the invention illustrated a common theme is the avoidance of an edge between an inner and outer flare projecting inwardly towards the interior of the external cavity 5 and the coupling loop 7. Investigation suggested that it was this edge featuring in the known construction illustrated in Figures 1 and 2 which tended to provoke arcing and thus the problems outlined hereinbefore. With the known construction of Figures 1 and 2 the electric field in the cavity tended to be concentrated at the welded edge of the inner and outer flares and high electric fields tended to be set up between the welded edge of the flares and the output loop 7 by means of which the power is coupled to an external transmission line and, subsequently, an aerial.

In the construction illustrated in Figure 3 the seal is effected by means of an annular ring 13 of cupro-nickel the inner rim 14 of which is secured between the cylindrical wall member 1 and the balance ring 12 by brazing. The outer rim 15 of the annular ring is formed into a radiused flange and the "turned-over" periphery is secured within the recess 8 to the outermost wall thereof. With this arrangement it will be seen that there is no edge projecting inwardly of the cavity 5. The smooth rounded surface presented by the flange outer rim 15 of the annular ring is not such as to induce arcing. At the same time the radiused configuration provides the degree of flexibility required to accommodate for the effects of differential expansion.

Referring to Figure 4 the construction shown here is not dissimilar to that shown in Figure 3 in that again the seal is effected by means of an annular ring 13 of cupro-nickel, but in this case it is the outer rim 16 of the ring 13 which is secured between the cylindrical wall member 1 and the balanced ring 12 by brazing. The inner rim 17 is formed as a radiused flange with its inner periphery turned to lie in a plane parallel to the plane of the outer rim 16 and secured, again by brazing, to the inner surface of the copper annulus 3 which faces the interior of the cylindrical section 1. Again the radiused portion of the inner rim 17 will accommodate for the effects of differential expansion whilst being removed from the interior of the external cavity 5 altogether.

In a modification to Figure 4 the inner periphery of the cupro-nickel ring 13, instead of being turned to lie in a plane parallel with the outer rim 16, is continued down into the recess 8 and fixed, by brazing to the inner wall of the recess 8.

Referring to Figure 5, in this arrangement the copper annulus 3 is stepped at its outer periphery 18 and the inner rim 19 of a flexible cupro-nickel ring 20 is brazed to the base of the step to form a seating for the balance ring 12. The outer periphery of the cupro-nickel ring 13 is turned down (as viewed) over the edge of annulus 3 and away from the interior of the external cavity 5. A thin cupro-nickel ring 21 has its inner rim 22 secured by brazing between the cylindrical wall member 1 and the balanced ring 12. The outer rim of the ring 21 is also turned down (as viewed) over the edge of annulus 3 away from the interior of the external cavity 5 to meet the external periphery of the ring 20. The edge thus formed is welded to complete the required vacuum joint. To provide a suitable contact for the spring fingers 4 of the box section forming the cavity 1 (which should not bear on the surface of the ring 21 because of the risk of burning at the finger contact and consequent puncturing of the ring), a copper collar 23 is fitted around the sealing ring 21. Copper collar 23 is fitted either by means of a screw thread or it is soldered to the underside (as viewed) of the copper annulus 3. Whilst in many ways this construction is reminiscent of that illustrated in Figure 2, nevertheless it will be appreciated that the welded edge uniting the outside peripheries of the rings 20, 21 does not extend inwardly towards the interior of the cavity 1, a smoothly rounded surface being presented in that direction.

CLAIMS

1. An external cavity klystron vacuum tube including a cylindrical section of wall transparent to electro-magnetic radiation and provided to be surrounded by an external resonant cavity, said wall section being sealed at its ends to other components of said tube by sealing means avoiding a sharp edge projecting inwardly towards the interior

of said cavity whereby to reduce the tendency for arcing to be induced between the sealing means and the interior of said external resonant cavity or an output probe provided therein.

2. A tube as claimed in claim 1 and wherein each end of said cylindrical wall section is closed by a copper annulus which, towards its outer periphery, has an annular recess, a flexible ring has an inner rim secured between the end of said cylindrical wall section and a balance ring member which bears upon the base of said recess, said ring member having an outer rim formed as a radiused flange which is secured around its periphery to the inner wall of said recess.

3. A tube as claimed in claim 2 and wherein said ring is secured between said cylindrical wall section and said balance ring member by brazing.

4. A tube as claimed in claim 2 or 3 and wherein said ring is attached to the inner wall member of said recess by brazing.

5. A tube as claimed in claim 1 and wherein each end of said cylindrical wall section is closed by a copper annulus which, towards its periphery, has an annular recess, a flexible ring has an outer rim secured between the end of said cylindrical wall section and a balance ring member which bears upon the base of said recess, said ring member having an inner rim formed as a radiused flange the inner periphery of which is secured to the inner surface of said copper annulus facing the interior of said cylindrical wall section.

6. A tube as claimed in claim 5 and wherein said ring is secured between said cylindrical wall section and said balance ring member by brazing.

7. A tube as claimed in claim 1 and wherein each end of said cylindrical wall section is closed by a copper annulus which is stepped at its outer periphery, the inner rim of a flexible ring being secured to the base of said step whilst the outer rim thereof is turned over the outer edge of said copper annulus away from the interior of said cavity, the inner rim of another flexible ring is secured between the end of said cylindrical wall section and a balance ring member which bears upon the inner rim of said first flexible ring member, the outer rim of said second ring member is turned over the outer edge of said copper annulus away from the interior of said cavity and the outer edges of said two ring members are united.

8. A tube as claimed in claim 7 and wherein a collar is provided attached to said annulus and extending over the outer rim of said second ring member, the collars at each end of said wall section providing abutments for the walls forming said external cavity.

9. A tube as claimed in claim 8 and wherein the walls of said external cavity terminate in spring fingers which bear upon said collars.

10. A tube as claimed in any of the above claims 2 to 9 and wherein said cylindrical wall member and said balance ring member are of ceramic material.

11. A tube as claimed in any of the above claims 2 to 10 and wherein said flexible ring or rings are of cupro-nickel.

12. A tube as claimed in claim 7, 8 or 9 and wherein the edges of said two flexible rings are united by welding.

13. A tube as claimed in any of the above claims 2 to 12 and wherein each annulus closing an end of said cylindrical wall section are of copper.

14. An external cavity klystron vacuum tube substantially as herein described with reference to Figure 3 of the accompanying drawings.

15. An external cavity klystrom vacuum tube substantially as herein described with reference to Figure 4 of the accompanying drawings.

16. An external cavity klystrom vacuum tube substantially as herein described with reference to Figure 5 of the accompanying drawings.

Amendments to the claims have been filed, and have the following effect:-

(a) Claims 1 - 16 above have been deleted or textually amended.

(b) New or textually amended claims have been filed as follows:-

1. An external cavity klystron vacuum tube including a cylindrical section of wall which is transparent to electro-magnetic radiation and provided to be surrounded by an external resonant cavity, said cylindrical wall section having an end closed by an annulus which, towards its outer periphery, has an annular recess, and wherein a flexible ring forming part of a sealing means sealed to said annulus is secured between the end of said cylindrical wall section and a balance ring member which bears upon the base of said recess, said flexible ring having a rim formed as a radiused flange extending into said recess.

2. A tube as claimed in claim 1 and wherein said radiused flange is secured around its periphery to a wall of said recess.

3. A tube as claimed in claim 2 and wherein said wall is the outermost wall of said recess.

4. A tube as claimed in claim 2 or 3 and wherein said ring is attached to said wall of said recess by brazing.

5. A tube as claimed in any of the above claims and wherein said flexible ring is secured between said cylindrical wall section and said balance ring member by brazing.

6. A tube as claimed in any of the above claims and wherein said cylindrical wall member and said balance ring member are of ceramic material.

7. A tube as claimed in any of the above claims and wherein said flexible ring is of cupro-nickel.

8. A tube as claimed in any of the above claims and wherein said annulus is of copper.

9. An external cavity klystron vacuum tube substantially as herein described with reference to Figure 3 of the accompanying drawings.

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